

CRASH DATA RESEARCH CENTER

Calspan Corporation
Buffalo, NY 14225

**CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO: CA09004**

VEHICLE: 2009 MERCEDES-BENZ ML 350

LOCATION: STATE OF PENNSYLVANIA

CRASH DATE: DECEMBER 2008

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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BACKGROUND

This on-site investigation focused on the crash dynamics of a 2009 Mercedes-Benz ML 350 (**Figure 1**) sport utility vehicle that was involved in a single vehicle run-off-road crash with a tree and subsequent rollover. The Mercedes-Benz was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system, front seat back mounted side impact air bags, rollover sensing curtain air bags for the four outboard positions, front buckle mounted safety belt pretensioners, and rear outboard retractor mounted pretensioners. The



Figure 1. Case vehicle, 2009 Mercedes-Benz ML 350.

The manufacturer of this vehicle has certified that the ML 350 is compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard No. 208. Additionally, the ML 350 was equipped with the Mercedes-Benz PRE-SAFE system. If the PRE-SAFE system detects that a crash is imminent it adjusts the passenger front seat, closes the side windows and sunroof, and utilizes electric tensioners to tighten the front safety belts. The vehicle was occupied by a restrained 49-year-old female driver. The driver sustained minor injuries and was transported to a hospital where she was treated and released the following day. As a result of the crash, the driver's pretensioner actuated and the driver's frontal air bag and both curtain air bags deployed.

This crash was identified by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) during a review of police crash reports submitted by the National Automotive Sampling System (NASS). Due to the rollover crash dynamics, the PAR was forward to the Calspan Special Crash Investigations team (SCI) for follow-up on January 30, 2009. The vehicle was located and cooperation was established with the repair facility to inspect the vehicle. An on-site investigation was assigned to the Calspan SCI team on February 3, 2009. The vehicle and the crash site inspections were conducted February 11, 2009.

SUMMARY

Crash Site

This crash occurred during the daylight hours of December 2008 on the north roadside of a two-lane east/west roadway. At the time of the crash, the road surface was dry and the weather conditions were reported as clear. The east/west roadway was configured with one travel lane in each direction. The travel lanes were surfaced with asphalt and separated by double yellow centerlines. The posted speed limit for the roadway was 40 km/h (25 mph). In the vicinity of the crash site, a north/south roadway intersected the east/west travel lanes forming a four-leg intersection. The intersection was controlled by stop signs for the north/southbound traffic. The roadsides were bordered by concrete barrier curbs. Beyond the north curb, the roadside consisted of a grass area with a tree line, concrete sidewalk, a lawn with a wooden fence, and a private residence. The scene schematic is included as **Figure 9** of this report.

Vehicle Data

2009 Mercedes-Benz ML 350

The 2009 Mercedes-Benz ML 350 was a four-door sport utility vehicle that was identified by Vehicle Identification Number (VIN) 4JGBB86E49A (production number deleted). The ML 350 was powered by a 3.5-liter six-cylinder engine linked to a seven-speed automatic transmission with all-wheel drive. The braking system consisted of power assisted front and rear disc brakes with an Antilock Braking System (ABS) and brake assist. The ML was also equipped with Electronic Stability Control (ESC) and traction control. The tires on the vehicle were Continental 4x4 Contact, size P255/50R19, mounted on five-spoke OEM alloy wheels. The vehicle manufacturer recommended cold tire pressure was 207 kPa (32 PSI) for the front and 262 kPa (38 PSI) for the rear. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Tire/Wheel Damage
Left Front	Tire Flat	6 mm (8/32")	Cut sidewall
Left Rear	200 kPa (29 PSI)	7 mm (9/32")	None
Right Front	200 kPa (29 PSI)	7 mm (9/32")	None
Right Rear	200 kPa (29 PSI)	7 mm (9/32")	None

The interior was configured with leather surfaced five-passenger seating. The front bucket seats were separated by a center console and were equipped with active head restraints that were height adjustable. The driver and front right head restraints were adjusted to 2 cm (0.8") and 3 cm (1.2") above the full-down position at the time of the SCI inspection, respectively. The rear seating consisted of a bench seat with a forward folding back feature and height adjustable head restraints.

The Mercedes-Benz ML 350's safety systems consisted of a CAC frontal air bag system, front seat back mounted side impact torso air bags, rollover sensing curtain air bags for the four outboard positions, front buckle mounted safety belt pretensioners, rear outboard retractor mounted pretensioners, and the Mercedes-Benz PRE-SAFE system.

Crash Sequence

Pre-Crash

The restrained 49-year-old female driver of the Mercedes-Benz was operating the vehicle eastbound on the two-lane roadway (**Figure 2**). The driver stated to the SCI investigator that she was stopped for a red light at an intersection. This intersection was located approximately 100 meters (328 feet) west of the crash site. While stopped at this intersection, the driver inhaled a dose of medication that she had recently purchased at a pharmacy. As the driver accelerated to continue her eastbound trajectory, she stated that she had a reaction to the medication which caused her to lose consciousness. The vehicle traveled approximately 100 meters (328 feet), and crossed the centerline, and traversed the westbound travel lane. It's unknown if the PRESAFE system activated prior to the crash.



Figure 2. Mercedes-Benz eastbound trajectory.

Crash

The vehicle departed the north roadside and the left front wheel impacted a curb (Event 1) that was 16 cm (6.3") in height. This impact did not alter the northeast trajectory of the Mercedes-Benz as it continued off-road. The vehicle traveled off-road 3.3 meters (10.8 feet) and impacted a 60 cm (23.6") diameter tree with the front left corner (Event 2). **Figure 3** depicts the curb and struck tree. The impact location was outboard of the left frame rail which allowed the vehicle to continue its forward movement. As the frontal components crushed, the left front wheel engaged the tree. During the engagement with the left front wheel, the rear of the vehicle began to lift off the ground. Additionally, the tree engagement induced a counterclockwise rotation. The ML 350 traveled approximately 3 meters (9.8 feet) as it continued to rotate and re-enter the westbound lane. The combination of the left front wheel engagement, rotation, lifting, and the center of gravity height caused the ML 350 to initiate a bounce-over rollover event as it returned to the roadway (Event 3). The vehicle landed on its right side and slid approximately 1 meter (3.2 feet) to final rest on its right side. As a result of the rollover event, the curtain air bags deployed in the vehicle.



Figure 3. Area of impact with the curb and the tree.

Although the impact with the tree was outboard the frame rail, a crush profile was documented along the front bumper and was used to calculate a delta-V with the Damage algorithm of the WINSMASH program. The total delta-V was 11 km/h (6.8 mph) with longitudinal and lateral components of -11 km/h (-6.8 mph) and 0 km/h, respectively.

Post-Crash

Police and emergency medical personnel responded to the crash site. The driver stated to the SCI investigator that she exited the vehicle through the hatch which was opened by a police officer. The driver sustained minor injuries and was transported to a hospital where she was treated and released the following day. The vehicle was placed in an upright position and towed from the crash site. The Mercedes-Benz was located a repair facility where it was inspected for this SCI investigation.

Vehicle Damage ***Exterior Damage***

The exterior of the 2009 Mercedes-Benz ML 350 sustained moderate severity damage as a result of the multiple event crash sequence (**Figures 4 and 5**). The left front wheel impacted the 16 cm (6.3”) curb (Event 1); however the damage from this impact was masked by subsequent tree impact. The Collision Deformation Classification assigned to this impact was 12-FLWN-3.

The tree impact to the front left corner resulted in deformation to the frontal components and extended down the left fender (**Event 2**). The direct contact damage measured 40 cm (15.7”) and began 50 cm (19.7”) left of the centerline; ending at the left corner. A crush profile was documented along the front bumper beam and was as follows: C1 = 24 cm (9.4”), C2 = 7 cm (2.8”), C3 = 0 cm, C4 = 0 cm, C5 = 0 cm, C6 = 0 cm. The left wheel and tire sustained damage that consisted of a cut to the sidewall of the tire and the front part of the rim was split circumferentially approximately 80 percent. The CDC for this event was 12-FLEE-3.

The damage from the rollover sequence (Event 3) was minor and consisted of abrasions of to the right side of the vehicle. **Figure 5** is an overall view of the right side. The abrasions were vertically oriented and scattered along the roof side rail, doors, fender, and quarter panel.



Figure 4. Residual frontal damage from the tree impact.



Figure 5. Overall view of the rollover damage to the right plane.

There was no deformation from the ground contact; however, the right mirror fractured off its mount and was compressed against the right front door resulting in deformation to the door. Additionally, the right front window disintegrated. The remainder of the glazing was closed and intact. All doors and the hatch remained closed during the crash and were operational post-crash. The CDC assigned to this impact was 00-RDAO-2.

Interior

The interior of the Mercedes-Benz was free of occupant contact points and intrusions. The driver's bucket seat track was adjusted between the mid-to-forward track. The seat back was located 28 degrees aft of vertical.

Manual Safety Belt Systems

The Mercedes-Benz was equipped with manual 3-point lap and shoulder safety belts for the five designated seat positions. All belt systems utilized continuous loop webbing with sliding latch plates. The driver's belt was equipped with an Emergency Locking Retractor (ELR), height adjustable D-ring that was in the mid position, and a buckle pretensioner. The driver used the safety belt at the time of the crash which was supported by the frictional abrasions to the latch plate, creasing of the webbing, and the actuated buckle pretensioner. Frictional abrasions were noted across the full width of the latch plate. The creasing of the webbing was located from 39 cm - 61 cm (15.4" - 24") above the anchor. The actuation of the buckle pretensioner compressed the buckle stalk 5 cm (1.9").

The front right safety belt system utilized a switchable ELR/Automatic Locking Retractor (ALR) and a buckle pretensioner. The three rear belt systems utilized switchable ELR/ALR and retractor pretensioner for the outboard positions. These positions were unoccupied at the time of the crash; however, all the pretensioners actuated during the crash.

Side Impact and Rollover Occupant Protection System's

The 2009 Mercedes-Benz ML 350 was equipped with rollover sensing curtain air bags for the four outboard positions. The left and right side curtain air bags deployed during the rollover event. **Figure 6** is an overall view of the left curtain air bag.



Figure 6. Deployed left curtain air bag.

The curtain air bags deployed from the respective roof side rails. The air bag membrane measured 183 cm (72") in length. At the front left seating position, the membrane was 49 cm (19.3") in height extending 7 cm (2.8") below the top of the door panel. The height of the curtain air bag membrane at the left rear position was 45 cm (17.7") and extended 5 cm (1.9") below the top of the door panel. The height

of the curtain air bag membrane provided head protection from the roof side rail to the belt line of the vehicle.

Longitudinally, the coverage area of these curtain air bags did not span across the front glazing. A triangular shaped gap was present which began at the A-pillars and extended 27 cm (10.6") rearward and was 30 cm (11.8") in height. The curtain air bags were tethered to the D-pillar by 42 cm (16.5") tethers.

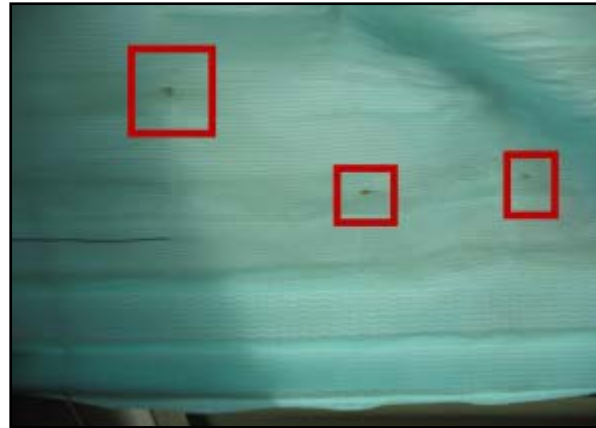


Figure 7. Close-up view of the brownish colored marks on the curtain air bag.

The curtain air bags were free of occupant contact points. Several brownish-colored marks that appeared to be burns were scattered throughout the membranes of both curtain bags. The curtain air bags were not punctured at the locations of these marks. **Figure 7** is a close-up of view of the marks on the left curtain air bag.

Additionally, the Mercedes-Benz was equipped with front seat back mounted side impact air bags. These air bags did not deploy during the crash.

Frontal Air Bag System

The Mercedes-Benz was equipped with a CAC frontal air bag system that consisted of dual stage driver and passenger air bags, seat track positioning sensors, a front right occupant presence sensor, front buckle mounted pretensioners, and safety belt buckle switches.

As a result of the frontal impact with the tree, the driver's frontal air bag deployed (**Figure 8**). The driver's frontal air bag was conventionally mounted within the center of the four-spoke steering wheel rim and was concealed by a five cover flap design. The top cover flap measured 9 cm (3.4") in height and 6 cm (2.4") in width. The four lower cover flaps were 4 cm (1.6") and 6 cm (2.4") in maximum width and 4 cm (1.6") and 7 cm (2.8") in height, respectively. The driver's air bag membrane measured 56 cm (22") in diameter in its deflated state. The air bag contained two tethers and was vented by two vent ports at the 11 and 1 o'clock positions. There was no damage or occupant contact points present on the air bag membrane.



Figure 8. Deployed driver's frontal air bag.

The front right seat was not occupied at the time of the crash; therefore, the CAC system suppressed the deployment of the passenger air bag.

Occupant Demographics/Data

Driver Age/Sex: 49-year-old female
 Height: 160 cm (63")
 Weight: 84 kg (185 lbs)
 Seat Track Position: Mid-to-forward track
 Manual Safety Belt Use: Manual 3-point lap and shoulder belt
 Usage Source: Vehicle inspection
 Egress from Vehicle: Under own power through rear hatch
 Mode of Transport
 From Scene: Ambulance
 Type of Medical Treatment: Treated and released the following day

Driver Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Source
Contusion to the right hip	Minor (890402.1,1)	Center console
Chest contusion	Minor (490402.1,0)	Safety belt
Lower lip abrasion	Minor (290202.1,8)	Frontal air bag
Cervical strain	Minor (640278.1,6)	Frontal air bag (Indirect)

Source = Interview and medical records

Driver Kinematics

The 49-year-old female driver was seated in a mid-to-forward track position and was restrained by the manual 3-point lap and shoulder belt system. Immediately prior to the crash, the driver had lost consciousness due to a reaction to an inhaled medication. The driver was slumped over in the driver’s seat as it departed the road and impacted a curb. This impact was minor and did not displace the driver. The vehicle continued forward 3.3 meters (10.8 feet) and impacted a 60 cm (23.6”) diameter tree with the front left corner. This actuated the driver’s buckle pretensioner and deployed the driver’s frontal air bag. The driver loaded the belt system resulting in the chest contusion.

Her slumped position placed her head near the outer limits of the deploying frontal air bag resulting in contact between the driver’s face and the air bag membrane. This contact produced the lower lip abrasion and a cervical strain.

The vehicle rolled over one-quarter turn onto its right side. During the rollover event, the left and right curtain air bags deployed. The driver was displaced to the right and possibly contacted the center console resulting in the right hip contusion. The driver exited the vehicle through the rear hatch. She was transported by ambulance to a local hospital where she was treated for her injuries and released. The combination of the driver’s restraint usage along with the actuation of the pretensioner and the deployment of the frontal and curtain air bag system, probably prevented further injuries to the driver in this crash.

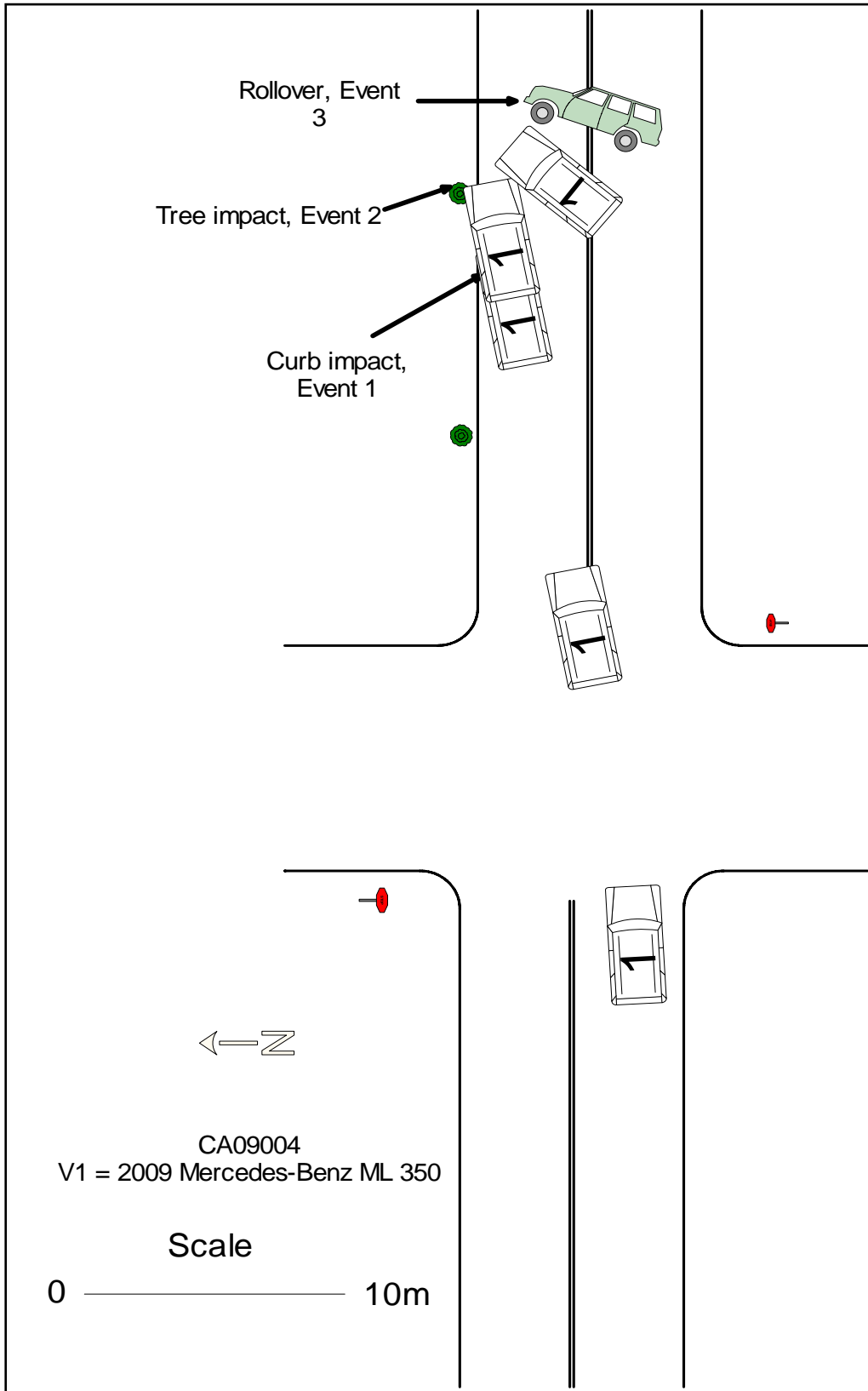


Figure 9: Scene Schematic